



(11)

**EP 4 528 101 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**26.03.2025 Bulletin 2025/13**

(51) International Patent Classification (IPC):  
**F03G 7/06** <sup>(2006.01)</sup> **F04D 27/02** <sup>(2006.01)</sup>

(21) Application number: **24199023.3**

(52) Cooperative Patent Classification (CPC):  
**F04D 27/0215; F03G 7/06114; F03G 7/0612;  
F03G 7/0613; F03G 7/064**

(22) Date of filing: **06.09.2024**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB  
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL  
NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA**  
Designated Validation States:  
**GE KH MA MD TN**

(71) Applicant: **Hamilton Sundstrand Corporation**  
**Charlotte, NC 28217-4578 (US)**

(72) Inventors:  
• **KILCHYK, Viktor**  
**Lancaster, 14086 (US)**  
• **MERRITT, Brent J.**  
**Southwick, 01077 (US)**

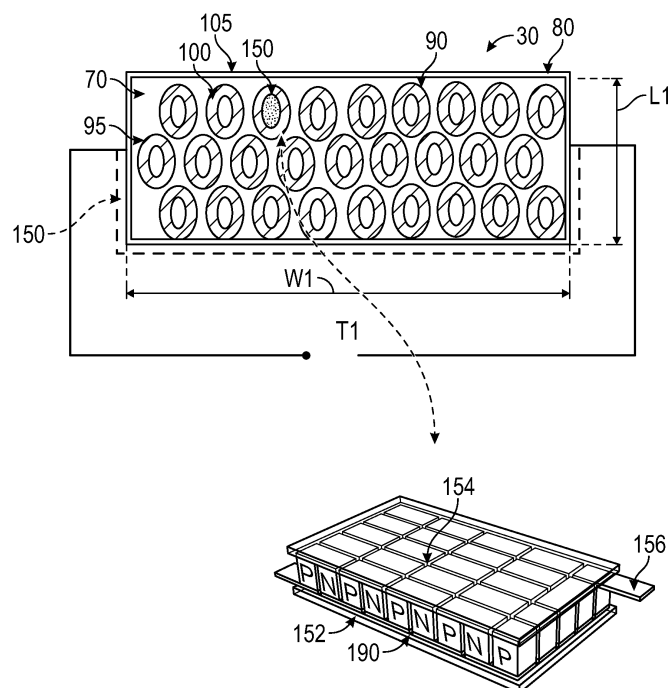
(30) Priority: **08.09.2023 US 202318464139**

(74) Representative: **Dehns**  
**10 Old Bailey**  
**London EC4M 7NG (GB)**

(54) **AIRCRAFT COMPONENT ADDITIVELY HAVING THERMALLY ADAPTIVE MATERIAL AND A THERMOELECTRIC JUNCTION**

(57) A device comprising a base (70) having an outer boundary (80) and a plurality of base voids (95), the base formed from a first material having a first coefficient of thermal expansion (CTE); beads (90) that line ones of the base voids, formed from a second material having a

second CTE that differs from the first CTE, wherein each of the beads has a bead void; and a thermoelectric junction (150) around the outer boundary, or within one or more of the bead voids.



**FIG. 2**

## Description

### BACKGROUND

**[0001]** The embodiments are directed to an aircraft component and more specifically to an aircraft component having a thermally adaptive material and a thermoelectric junction.

**[0002]** Memory shape alloys may be utilized for various turbomachinery applications to avoid the requirement of utilizing complex machinery. However, working fluid temperatures may undesirably control the shape of the alloy.

### BRIEF DESCRIPTION

**[0003]** Disclosed is a device, including: a base having an outer boundary and a plurality of base voids, formed from a first material having a first coefficient of thermal expansion (CTE); beads that line ones of the base voids, formed from a second material having a second CTE that differs from the first CTE, wherein each of the beads has a bead void; and a thermoelectric junction around the outer boundary, or within one or more of the bead voids.

**[0004]** In embodiments, the thermoelectric junction is a Peltier device.

**[0005]** In embodiments, one or more of the first material and the second material is a bistable metal, alloy or composite.

**[0006]** In embodiments, a base outer surface is formed from the second material.

**[0007]** In embodiments, the device is a compressor case of a cabin air compressor.

**[0008]** In embodiments, a section of the device defines a bypass port that is opened or closed by driving current, through the thermoelectric junction, in a first direction or a second direction.

**[0009]** A cabin air compressor including a device having one or more of the above aspects is also provided.

**[0010]** Disclosed is another device, including a base, formed from a first material having a first CTE, that extends in a first direction from first side to a second side and in a second direction from a first end to a second end; and a thermoelectric junction disposed between the first and second sides, so that the thermoelectric junction extends between the first and second ends, to thereby define: a first layer of the base that is between the thermoelectric junction and the first side of the base; and a second layer of the base that is between the thermoelectric junction and the second side of the base.

**[0011]** In embodiments, the thermoelectric junction is a Peltier device.

**[0012]** In embodiments, the first material is a bistable metal, alloy, or composite.

**[0013]** In embodiments, the device is configured so that driving a current through the thermoelectric junction heats the first layer of the base relative to the second layer of the base to change a shape of the base.

**[0014]** In embodiments, the device is a compressor

case of a cabin air compressor.

**[0015]** A cabin air compressor including a compressor case having one or more of the above disclosed aspects is also provided.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0016]** The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

FIG. 1A shows an aircraft according to an embodiment;

FIG. 1B shows a component of the aircraft according to an embodiment;

FIG. 2 shows a section of the component in a normal state, with a base that defines voids that are respectively lined with beads that define bead voids, where the beads have a coefficient of thermal expansion (CTE) that is selected to provide a predetermined deformation when subjected to thermal input, and where a thermoelectric junction is formed either within at least one of the bead voids or around the base;

FIG. 3 shows the section of FIG. 2 in a deformed state;

FIG. 4 shows another configuration of the section of the component in the normal state, with a base formed of a material having a CTE that is selected to provide a predetermined deformation when subjected to heating, and where a thermoelectric junction is formed within the base; and

FIG. 5 shows the section of FIG. 4 in a deformed state.

### DETAILED DESCRIPTION

**[0017]** A detailed description of one or more embodiments of the disclosed apparatus are presented herein by way of exemplification and not limitation with reference to the Figures.

**[0018]** FIG. 1A shows an aircraft 1 having a fuselage 2 with a wing 3 and tail assembly 4, which may have control surfaces 5. The wing 3 may include an engine 6, such as a gas turbine engine, and an auxiliary power unit 7 may be disposed at the tail assembly 4. The aircraft 1 may have a cabin air compressor 25. FIG. 1B shows additional details of the cabin air compressor 25, which may include a compressor case 30 (or more generally, a device or component 30) with a rotating shaft 31 and a rotating compressor blade 32 with seals 33. The component 30 may be a compressor case of the cabin air compressor 25. A bypass port 40 may be formed in a section 50 of the component 30 to allow passage of a flow from the com-

pressor 60.

**[0019]** In one embodiment, as shown in FIG. 2, the component 30 may be, e.g., additively manufactured, to define a base 70 formed of a first material. The base 70 may define an outer boundary 80 and internal base voids 95 or cavities. The base voids 95 may be lined with a second material, that differs from the first material, to form individual beads 90. The beads 90 may respectively define bead voids 100 or cavities. The second material may also cover the outer boundary 80 of the base 70 to form a base outer surface 104. A thermoelectric junction 150 may be disposed in one more of the bead voids 100, or may be disposed around the boundary of the base 70.

**[0020]** The beads 90 may be formed of a bistable metal, alloy or composite. The beads 90 have an oval cross section, though other shapes are within the scope of the disclosure. The base voids 95 have a shape that is complementary to the shape of the beads 90. The beads 90 are configured to change shape by a predetermined amount when subject to thermal input (e.g., heat) due to the coefficient of thermal expansion (CTE) of the second material. For example, when the beads 90 are subject to thermal input, shape of the base 70 may change from a first state (FIG. 2) to a second state (FIG. 3). In the first state, the base 70 may extend in a first direction (or length direction) to define a first length L1 and in a second direction (or width direction) to define a first width W1 (FIG. 2). In the second state the base 70 may have extend in the first direction to define a second length L2 and in the second direction to define a second width W2 (FIG.3). From the shape change, one of the first length and width L1, W1 may be greater than or less than a corresponding one of the second length and width L2, W2. In the illustrated embodiment, the second width W2 is less than the first width W1 and the first and second lengths L1, L2 are the same as each other.

**[0021]** A thermoelectric junction 150 may be disposed in one more of the bead voids 100, or may be disposed around the boundary 80 of the base 70. The thermoelectric junction 150 may be a Peltier device or a Thomson device. For example, alternating P and N-type pillars made with materials with different Seebeck coefficients, or legs, are placed thermally in parallel to each other and electrically in series and joined with a thermally conducting plate on each side, e.g., ceramic, including a cooling plate 152 and a heating plate 154. When a voltage is applied to the free ends of the two semiconductors, via connections 156 there is a flow of DC current across the junction of the semiconductors, causing a temperature difference. The side with the cooling plate 152 absorbs heat which is then transported by the semiconductor to the other side of the device. One of the cooling plate 152 or heating plate 154 may be exposed to the atmosphere if desired to bleed energy from it rather than directing energy from it back to the component 10.

**[0022]** In another embodiment, shown in FIG. 4, the component 30 may be, e.g., additively manufactured, with a base 70 formed of a substantially unitary material

and a thermoelectric junction 150 formed within the base 70. The base 70 may have a CTE that is selected to provide a predetermined deformation when subjected to thermal input. For example, the base 70 may extend in the first direction (the length direction) between first and second ends 160, 170 and the second direction (the width direction) between first and second side 180, 190. The thermoelectric junction 150 may be disposed between the first and second sides 180, 190 and extend in the first direction between the first and second ends 160, 170. This configuration defines a first layer 200 of the base 70, between the junction 150 and the first side of the base 70, and a second layer 210 of the base 70, and a second layer of the base 70, between the junction 150 and the second side 190 of the base 70.

**[0023]** The base 70 may be formed of a bistable metal, alloy or composite and extends in a first direction to define a first width W1 and in a second direction to define a first length L1. When subjected to differential thermal input by the thermoelectric junction 150, such as heating only one layer 200, 210 of the base 70, the base 70 may deform as shown in FIG. 5 to form an arcuate shape. When in the deformed state, a longer side of the base 70 may have a length L2 that is greater than the first length L1, though projected along first direction the base 70 has a second length L2x that is shorter than the first length L1. The width may be unchanged.

**[0024]** As can be appreciated, utilizing disclosed material configuration shown in FIG. 2 to form the component 30 as the case with the bypass port 40, the bypass port 40 may be selectively opened or closed by applying thermal input to the material. That is, the port 40 may be opened or closed by driving current, through the thermoelectric junction, in a first direction or a second direction. That is, a controllable bypass port 40 may be obtained without the need for a movable part.

**[0025]** The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

**[0026]** Those of skill in the art will appreciate that various example embodiments are shown and described herein, each having certain features in the particular embodiments, but the present disclosure is not thus limited. Rather, the present disclosure can be modified to incorporate any number of variations within the scope of the invention as defined by the claims.

**Claims****1.** A device, comprising:

a base (70) having an outer boundary and a plurality of base voids (95), formed from a first material having a first coefficient of thermal expansion, CTE;  
beads (90) that line ones of the base voids, formed from a second material having a second CTE that differs from the first CTE, wherein each of the beads has a bead void; and  
a thermoelectric junction (150) around the outer boundary, or within one or more of the bead voids.

**2.** The device of claim 1, wherein:

the thermoelectric junction is a Peltier device.

**3.** The device of claim 1 or 2, wherein:

one or more of the first material and the second material is a bistable metal, alloy or composite.

**4.** The device of claim 1, 2 or 3, wherein:

a base outer surface (104) is formed from the second material.

**5.** The device of any preceding claim, wherein the device is a compressor case of a cabin air compressor (25).**6.** The device of claim 5, wherein:

a section of the device defines a bypass port (40) that is opened or closed by driving current, through the thermoelectric junction, in a first direction or a second direction.

**7.** A cabin air compressor comprising the device of claim 5.**8.** A device comprising:

a base (70), formed from a first material having a first CTE, that extends in a first direction from first side to a second side and in a second direction from a first end to a second end; and  
a thermoelectric junction (150) disposed between the first and second sides, so that the thermoelectric junction extends between the first and second ends, to thereby define: a first layer of the base that is between the thermoelectric junction and the first side of the base;  
and a second layer of the base that is between the thermoelectric junction and the second side of the base.

**9.** The device of claim 8, wherein:

the thermoelectric junction is a Peltier device.

**10.** The device of claim 8 or 9, wherein:

the first material is a bistable metal, alloy, or composite.

**11.** The device of claim 8, 9 or 10, wherein:

the device is configured so that driving a current through the thermoelectric junction heats the first layer of the base relative to the second layer of the base to change a shape of the base.

**12.** The device of any of claims 8 to 11, wherein the device is a compressor case of a cabin air compressor (25).**13.** A cabin air compressor comprising the compressor case of claim 12.

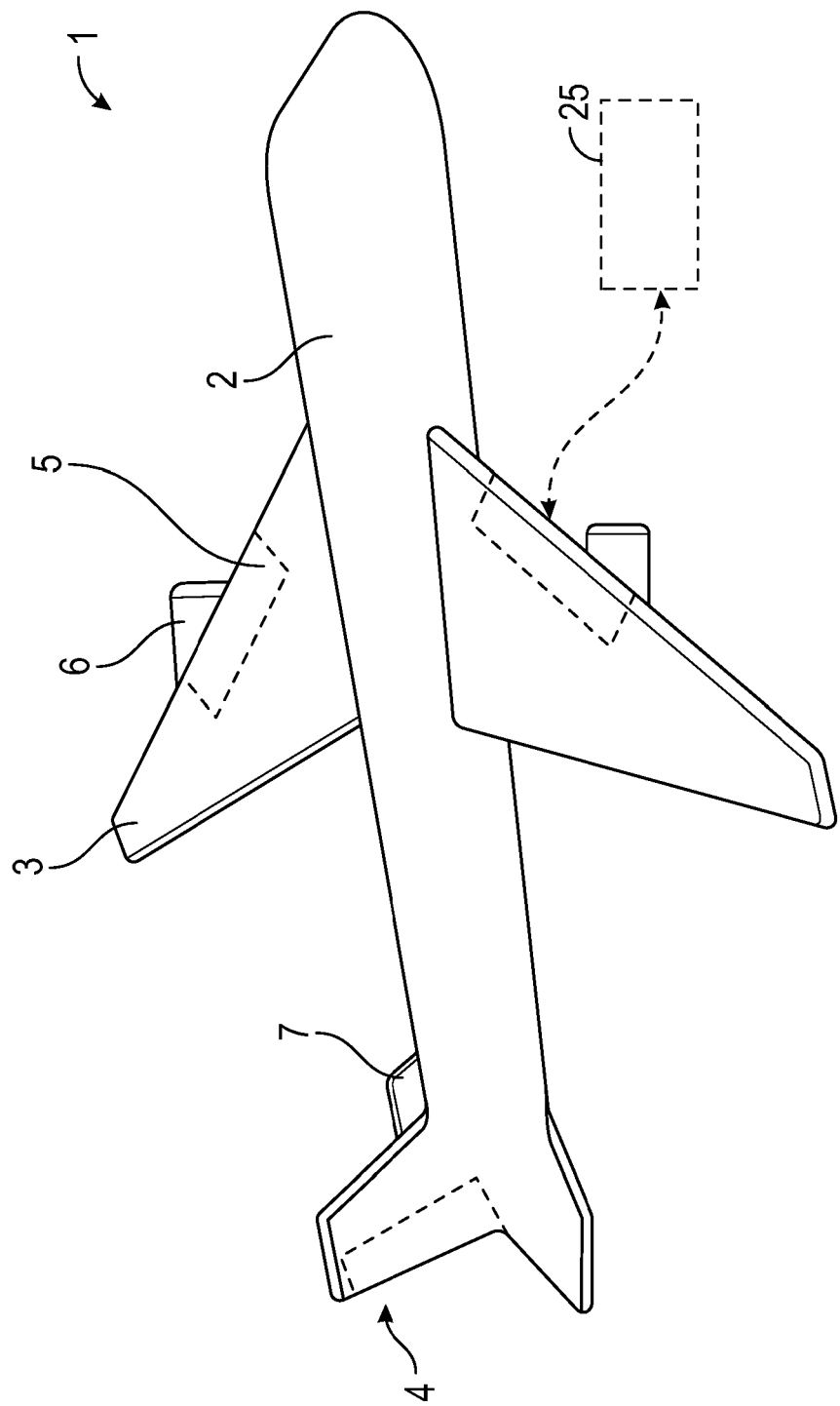
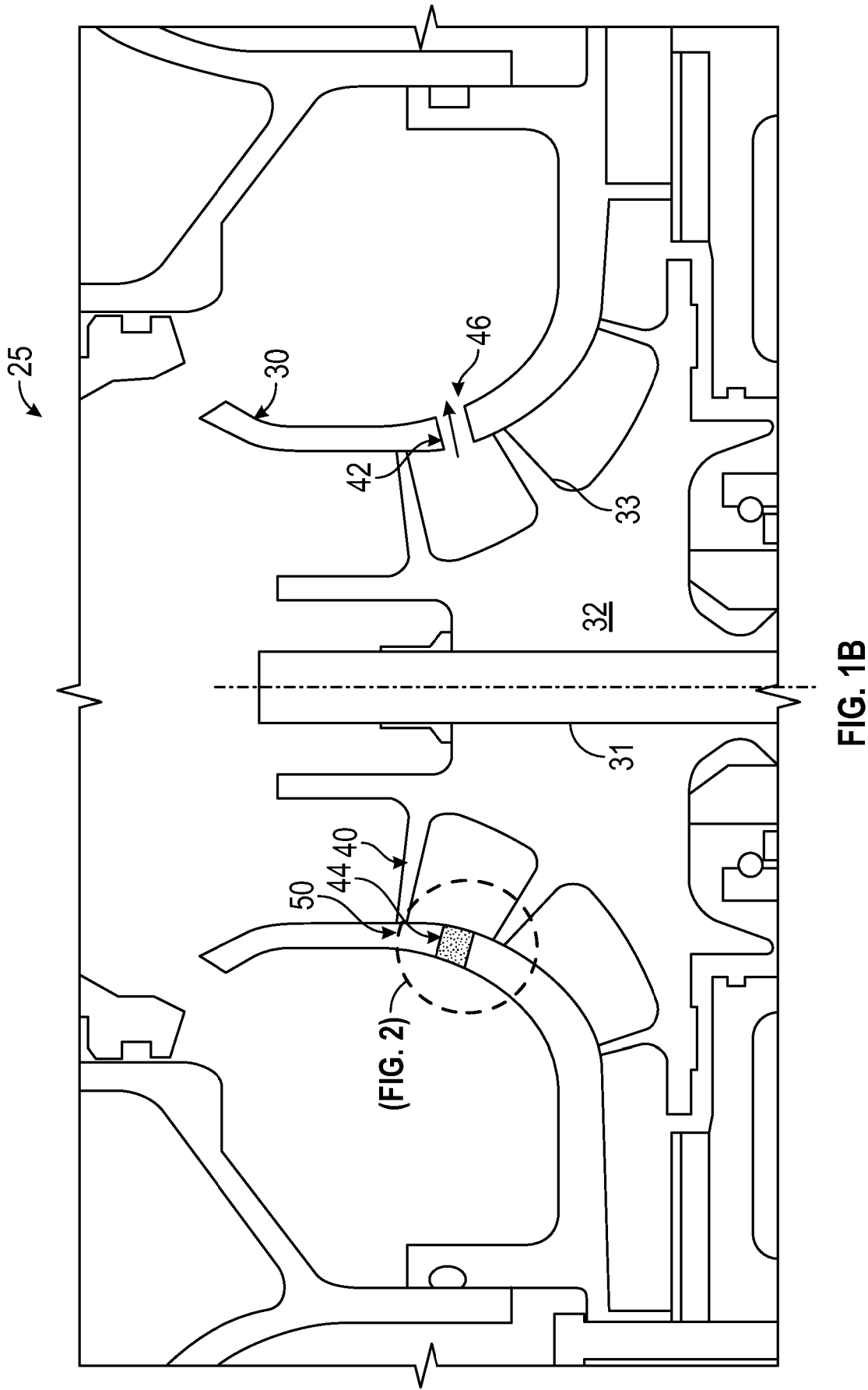
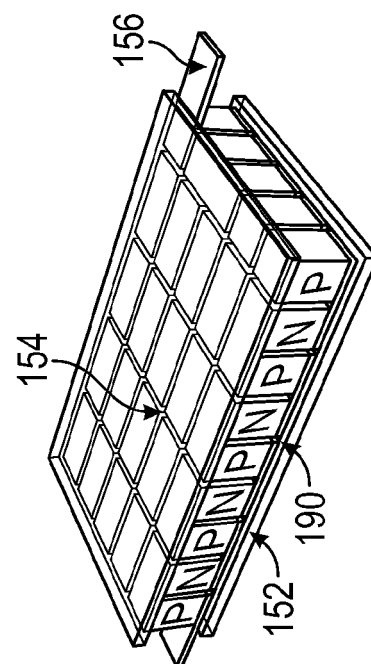
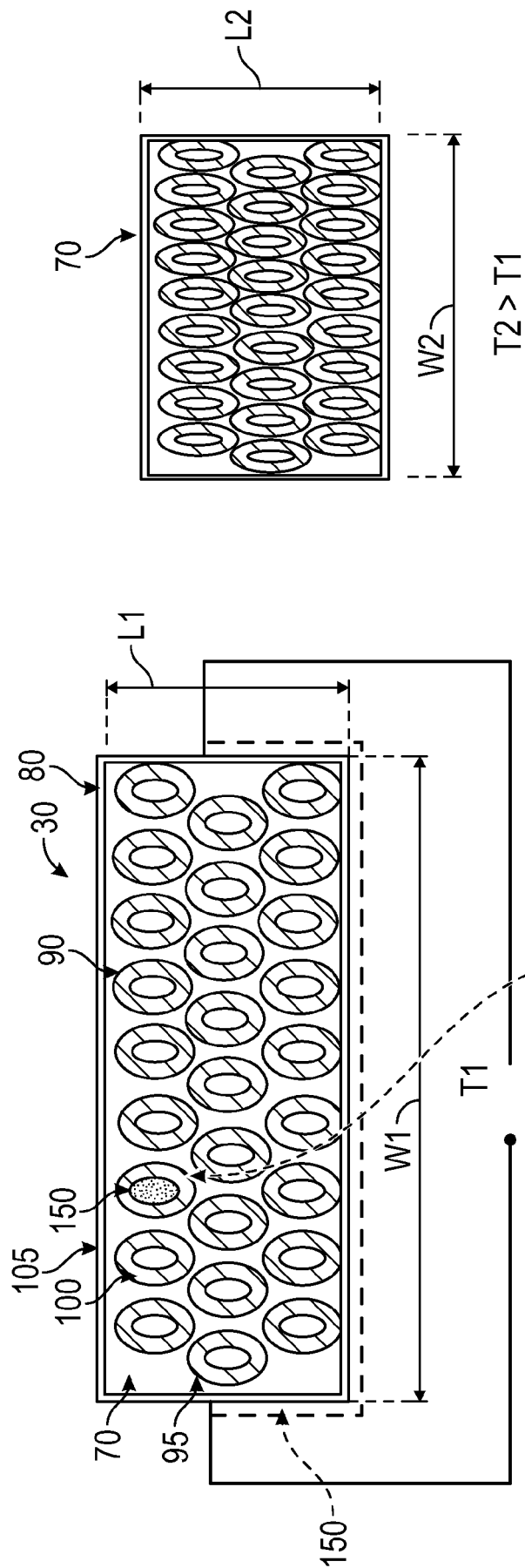
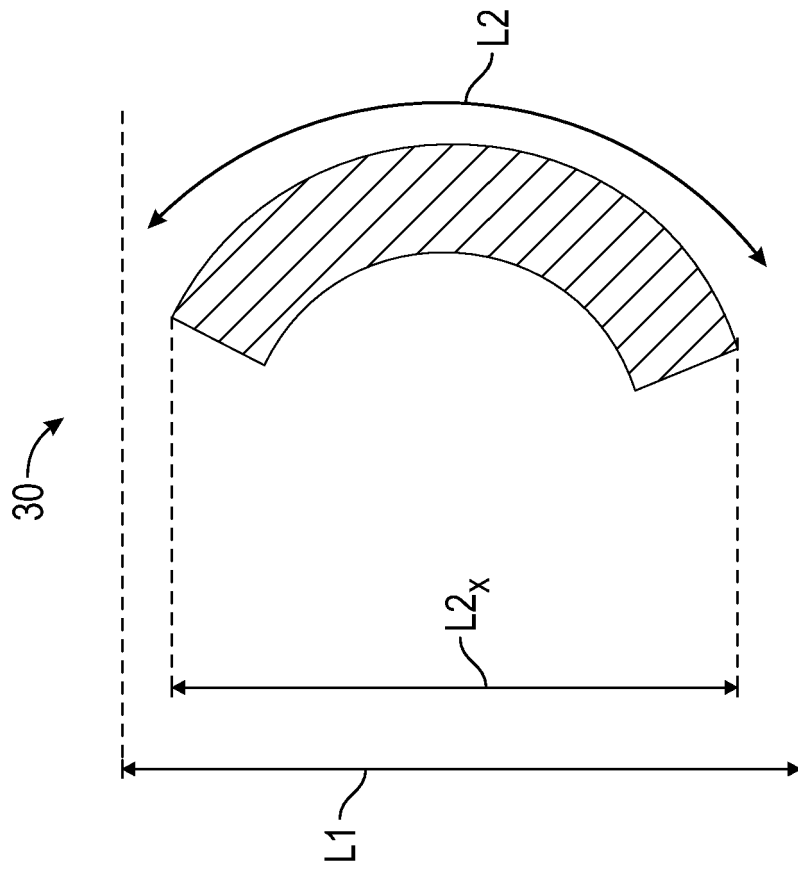
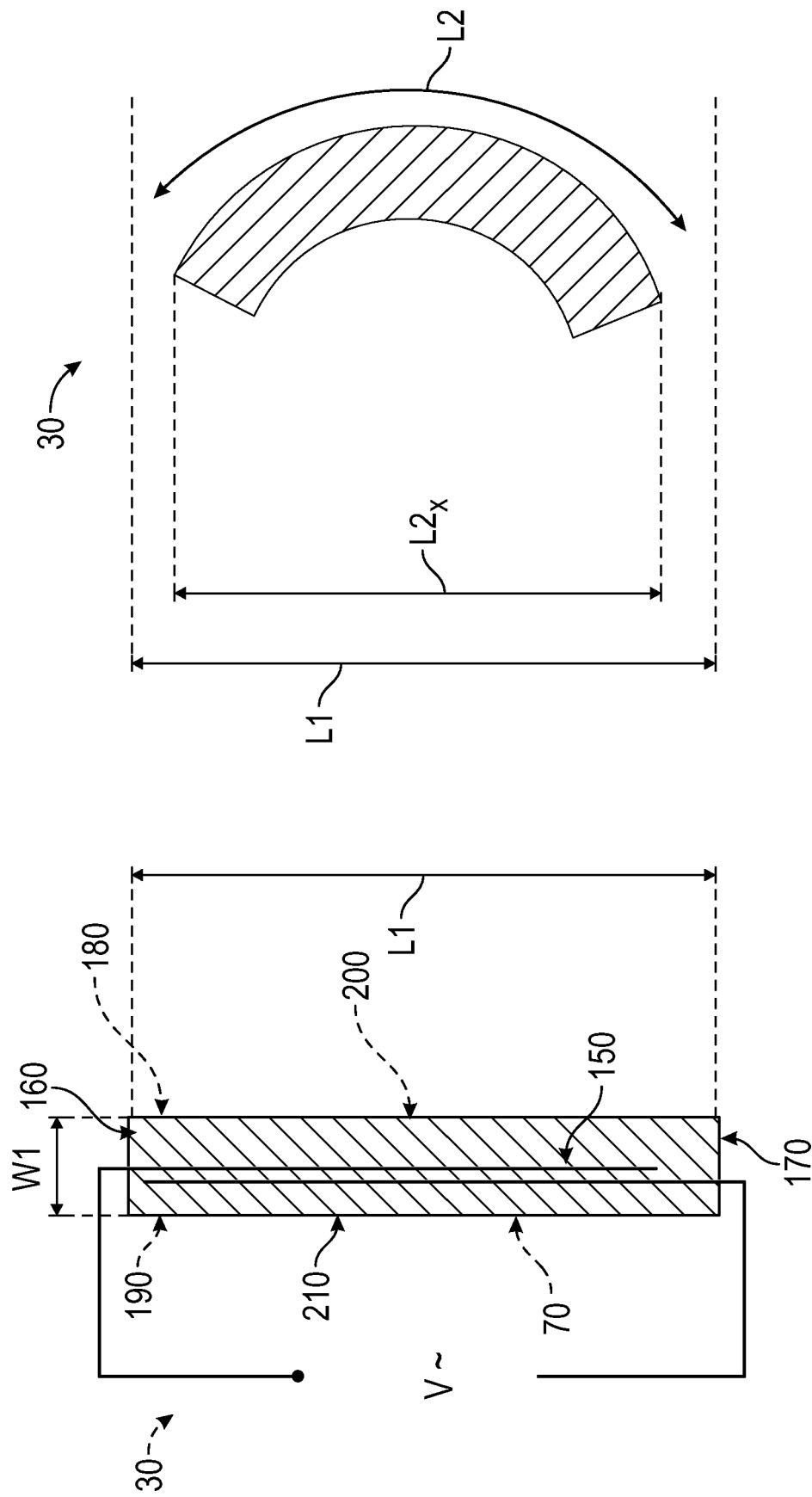


FIG. 1A









## EUROPEAN SEARCH REPORT

Application Number

EP 24 19 9023

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category                                                                                                                                                                                                                                                                              | Citation of document with indication, where appropriate, of relevant passages                                                                                         | Relevant to claim                | CLASSIFICATION OF THE APPLICATION (IPC) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------|
| X                                                                                                                                                                                                                                                                                     | US 6 161 382 A (BROTZ GREGORY R [US])<br>19 December 2000 (2000-12-19)                                                                                                | 8-13                             | INV.                                    |
| A                                                                                                                                                                                                                                                                                     | * column 4, lines 14-32; figures 8,9 *<br>-----                                                                                                                       | 1-7                              | F03G7/06<br>F04D27/02                   |
| A                                                                                                                                                                                                                                                                                     | EP 2 960 497 B1 (G RAU GMBH & CO KG [DE])<br>28 December 2016 (2016-12-28)<br>* paragraph [0055]; figure 1 *<br>-----                                                 | 1-13                             |                                         |
| A                                                                                                                                                                                                                                                                                     | US 2007/184238 A1 (HOCKADAY ROBERT G [US]<br>ET AL) 9 August 2007 (2007-08-09)<br>* paragraphs [0060] - [0063], [0487] -<br>[0491]; figures 3A, 3B, 4A, 4B *<br>----- | 1-13                             |                                         |
|                                                                                                                                                                                                                                                                                       |                                                                                                                                                                       |                                  | TECHNICAL FIELDS<br>SEARCHED (IPC)      |
|                                                                                                                                                                                                                                                                                       |                                                                                                                                                                       |                                  | F03G<br>F04D                            |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                            |                                                                                                                                                                       |                                  |                                         |
| Place of search                                                                                                                                                                                                                                                                       |                                                                                                                                                                       | Date of completion of the search | Examiner                                |
| Munich                                                                                                                                                                                                                                                                                |                                                                                                                                                                       | 11 February 2025                 | de Martino, Marcello                    |
| CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                                                                                           |                                                                                                                                                                       |                                  |                                         |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document                                                               |                                                                                                                                                                       |                                  |                                         |
| T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                                                                       |                                  |                                         |

EPO FORM 1503 03.82 (P04C01)



Application Number

EP 24 19 9023

**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

**LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

**see sheet B**

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



# LACK OF UNITY OF INVENTION SHEET B

Application Number

EP 24 19 9023

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

## 1. claims: 1-13

The special technical features, representing the contribution over the above mentioned prior art, of claim 1 are that:

- the base has an outer boundary and a plurality of base voids;
- beads that line ones of the base voids, formed from a second material having a second CTE that differs from the first CTE, wherein each of the beads has a bead void; and
- the thermoelectric junction is placed around the outer boundary, or within one or more of the bead voids.

These distinguishing special technical features result in that the device can expand or contract along two directions perpendicular to each other (respectively from L1 to L2 as well as from W1 to W2; cf. Figures 2, 3), whereas the base voids and the bead voids allow a considerably increased degree of expansion or contraction. Thus, even the two-dimensional cross-section of a large port can be closed or opened.

Therefore, the problem to be solved by these distinguishing features may be regarded as to provide an improved device that is of fast response to close or open a large cross-section of a fluid port.

## 1.1. claims: 8-13

On the other hand, the special technical features, representing the contribution over the prior art, of claim 8 are that:

- the base is formed from a first (integral) material (cf. Figure 4 and the base 70 with the uniform hatching).

These distinguishing special technical features result in that the device is compact, low cost and can expand or contract along one direction (respectively from L1 to L2 or L2x; cf. Figures 4, 5) and only with the aid of a thermoelectric activation.

Therefore, the problem to be solved by these distinguishing features may be regarded as to provide an improved device that is of simple and compact design and exerts a strong actuation or shifting force in one direction.

---

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 24 19 9023

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11 - 02 - 2025

10

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| US 6161382 A                              | 19-12-2000          | US 6161382 A               | 19-12-2000          |
|                                           |                     | WO 0248507 A1              | 20-06-2002          |
| -----                                     |                     | -----                      |                     |
| EP 2960497 B1                             | 28-12-2016          | DE 102014107821 A1         | 17-12-2015          |
|                                           |                     | EP 2960497 A2              | 30-12-2015          |
| -----                                     |                     | -----                      |                     |
| US 2007184238 A1                          | 09-08-2007          | US 2007184238 A1           | 09-08-2007          |
|                                           |                     | WO 2007092386 A2           | 16-08-2007          |
| -----                                     |                     | -----                      |                     |

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82